Artificial Intelligence

→ Intelligence is:
- the ability to reason
- the ability to understand
- the ability to create
- the ability to learn from experiences
- the ability to plan and execute complex tasks.

→ **Artificial Intelligence (AI)** is an area of computer science that emphasizes the creation of intelligent machines that works and react like humans.

→ Different definitions of AI can be divided into 2×2 matrix:

"thought process & reasoning"

system that think like humans	system that think rationally
system that act like humans	system that act rationally

"behaviour"

- Top dimensions is concerned with thought processes and reasoning, where as bottom dimension addresses the behavior.
- The def^n on the left measures the success in terms of fidelity of human performance, whereas definitions on the right measures an ideal concept of intelligence, which is called rationality.

* **Acting Humanly: The turing test Approach**

Def^n: The art of creating machines that perform functions

that requires intelligence when performed by people.
According to this test, a computer needs to interact with human interrogator by answering his questions in written format. Computer passes the test if human interrogator cannot identify whether the written responses from a person or a computer.
To pass a Turing test, a computer must have following capabilities:
a) Natural language processing:
Must be able to communicate successfully in english.
b) knowledge representation:
To store what it knows and hears.
c) Automated reasoning:
Answer the questions based on the stored information.
d) Machine learning:
Must be able to adapt in new circumstances.

* Thinking Humanly : Cognitive science Approach

Def^n: The exciting new effort to make computers think machines with minds, in the full and literal sense.
Cognitive science is interdisciplinary field which combines computer models from AI with the techniques of psychology in order to construct precise and testable theories for working of human mind.
In order to make machines think like human, we need to first understand how human think.
There are two ways using which human's thinking pattern can be caught.
a) Through introspection: Catch our thoughts while they go by.
b) Through psychological experiments: can be carried out by

observing a person in action.

By catching the human thinking pattern it can be implemented in computer system as a program and if the program's i/p and o/p matches with that of human, then it can be claimed that the system can operate like humans.

* Thinking Rationally : The laws of thought approach

Def^n : The study of mental faculties through the use of computational models.

The laws of thought are supposed to implement operation of the mind and their study initiated the field called logic. It provides precise notations to express facts of the real world.

It also includes reasoning and "right thinking" that is irrefutable thinking process. Also computer program based on these logic notations were developed to create intelligent system.

* Acting Rationally : The rational agent approach

Def^n : Computational intelligence is the study of the design of intelligent agents.

Rational Agent

Agent perceive their environment through sensors over a prolonged time period and adapt changes to create and pursue goals and take actions through actuators to achieve those goals. A rational agent is the one that does the right things and acts rationally so as to achieve the best outcome even when there is uncertainty in knowledge.

Applications of AI

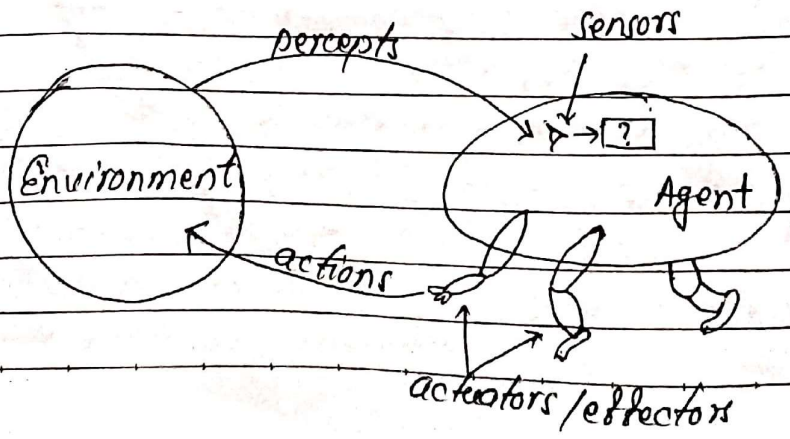
- Game playing
- speech recognition
- Expert system
- Understanding natural language
- Computer vision
- E-commerce
- Heuristic classification
- Robotics
- Autonomous control
- Problem solving
- Autonomous planning and scheduling

Intelligent Agents

An intelligent agent is anything that can percieve its environment through sensors and acts rationally upon that environment through its effectors and directs its activity towards achieving goals.

For e.g.

- Human agent
  - Eyes, ears, and other organs for sensors
  - legs, mouth and other body part for actuators
- Robotic agent
  - camera for sensors
  - motor for actuators

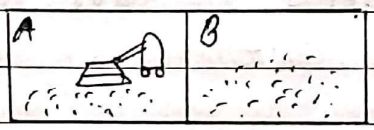


→ The agent function is mathematical concept that maps percept sequence to actions.

$$f : P^* \rightarrow A$$

properties of the agent:
- Autonomous
- Interacts with other agent plus the environment
- Reactive to the environment
- Pro-active (goal-directed)

Example of Agent:
The vacuum-cleaner world



Environment: Square A and B
Percepts : [location and content]
Actions : left, right, suck & no-op.

Pereept sequence	Action
[A, clean]	Right
[A, Dirty]	suck
[B, clean]	left
[B, Dirty]	suck
....	...

*Sensors/Percepts and effectors/actions

For Human:
- sensors : Eyes, ears, skin, tongue, nose, neuromuscular system

- Percepts : objects in the visual field (location, textures, colors, ...), auditory streams (pitch, loudness, direction), ...
- Effectors : limbs, digits, eyes, tongue, ...
- Actions : lift a finger, turn left/right, walk, run, ...

Automated taxi driving system

- Percepts : video, sonar, speedometer, odometer, engine sensors, keyboard input, GPS, ...
- Actions : steer, accelerate, brake, horn, speak/display, ...
- Goals : Maintain safety, reach destination, obey laws, provide passenger comfort, ...
- Environment : Urban streets, freeways, traffic, pedestrians, ~~weather~~ weather, customers, ...

Rational Agent

- A rational agent is an agent which has clear preferences and models uncertainity via expected value.
- A rational agent always performs right action, right action means the action that causes the agent to be most successful in the given percept sequence.
- Rational agent is capable of taking best possible action in any situation.

For every possible percept sequence, the rational agent is expected to take an action that will maximize its performance measure.

The agent's rational behavior depends on:
- performance measure
- prior environment knowledge

- Actions
- percept sequence up to now

Rationality

- Rationality is nothing but status of being reasonable, sensible, and having good sense of judgment.
- It is concerned with expected actions and results depending upon what the agent has perceived.
- Performing actions with the aim of obtaining useful information is an important part of rationality.

Environment

To design a rational agent we need to specify a task environment. Task environment means: PEAS

P : performance measure
E : Environment
A : Actuators
S : sensors

E.g.

① Fully automated taxi
P : safety, fast, legal, comfortable, profit
E : Roads, other traffic, pedestrians, weather
A : steering, accelerating, brake, horn, speaker/display
S : Cameras, sonar, speedometer, GPS, keyboard

② Vaccum cleaner
P : low electricity, cleaner, low noise, throughput, ..

E : Room, robot, object, dirty, ..
A : wheel, motor, sucker pipe, ..
S : dust sensor, optical sensor, ..

* Environment types / properties of environment

An environment is everything in the world which surrounds the agent, but it is not a part of an agent itself. An environment can be described as a situation in which an agent is present.

1. Fully observable vs Partially observable

If an agent sensor can sense or access the complete state of an environment at each point of time then it is a fully observable environment else it is partially observable.

For e.g.

Fully observable
→ 8-puzzle problem
→ 4-queen problem
→ Tic-toe problem

Partially observable
→ weather forcasting system
→ Automated taxi system
↳ a taxi agent doesn't has sensors to see what other drivers are doing.

2. Deterministic vs stochastic

The next state of the environment is completely determined by the current state and the action executed by the agent, then the environment is deterministic, otherwise it is stochastic.

→ stochastic means the environment changes while agent is taking action, hence the next state of world doesn't depends on the current state.

E.g.

Deterministic	stochastic
→ vacuum world	→ taxi driving
	→ Medical diagnosis
	→ Part-Picking robot
	→ Refinery Controller.

3. Episodic vs sequential

In Episodic environment, the agent's experience is divided into atomic "episodes" (each episode consists of the agent perceiving then performing a single action i.e. agent's single pair of perception & action) and every episode is independent of each other. The subsequent episodes do not depend on actions occured in previous episodes.
For E.g. an agent sorting defective parts in an assembly line, Pick & Place robot agent.

In sequential environment, current actions may affect all future decisions. In sequential environment, an agent requires memory of past action to determine the next best action. For E.g. a taxi driving agent or chess playing agent.

4. static vs Dynamic

If the environment changes while the agent is performing some tasks then it is called as dynamic environment.

For e.g. Taxi driving as the environment keeps changing all the time.

If the environment remains unchanged while the agent is performing given tasks then it is called as static environment.
For e.g. Vacuum cleaner, crossword puzzle solver.

5. Discrete vs continuous

If an an environment there are a finite number of percepts and actions that can be performed within it then such environment is called a discreted environment else it is called continuous environment.
For e.g.
- A chess game is discrete environment as there is a finite number of moves that can be performed.
- A self driving car is an e.g. of continuous environment.

6. Single Agent vs Multiagent

If only one agent is involved in an ~~eng~~ environment and operating by itself then such environment is called single agent environment. For e.g. an agent solving a crossword puzzle is in a single agent environment.

If multiple agents are operating in an environment, then such an environment is called a multiagent environment. For e.g. Agent in chess playing is in two-agent environment.

Medical Diagnosis
- Partially
- stochastic
- sequential
- Dynamic
- Continuous
- single agent

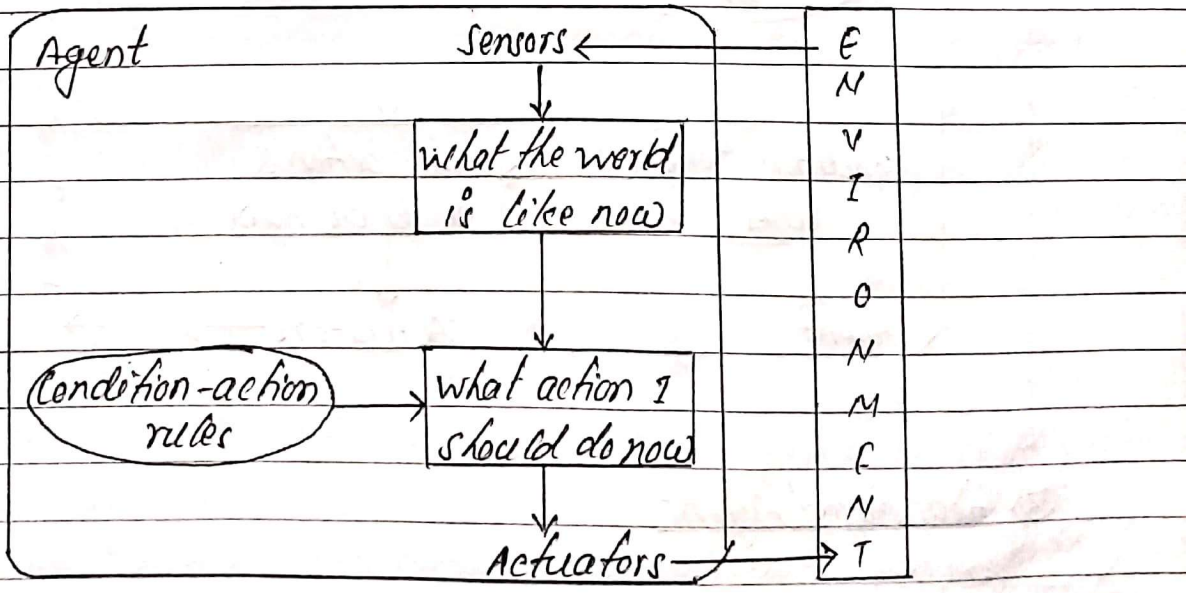
Part-picking robot
- Partially
- stochastic
- Episodic
- Dynamic
- Continuous
- single agent

Refinery Controller
- partially
- stochastic
- sequential
- Dynamic
- Discrete
- multiagent

* Types of Agents

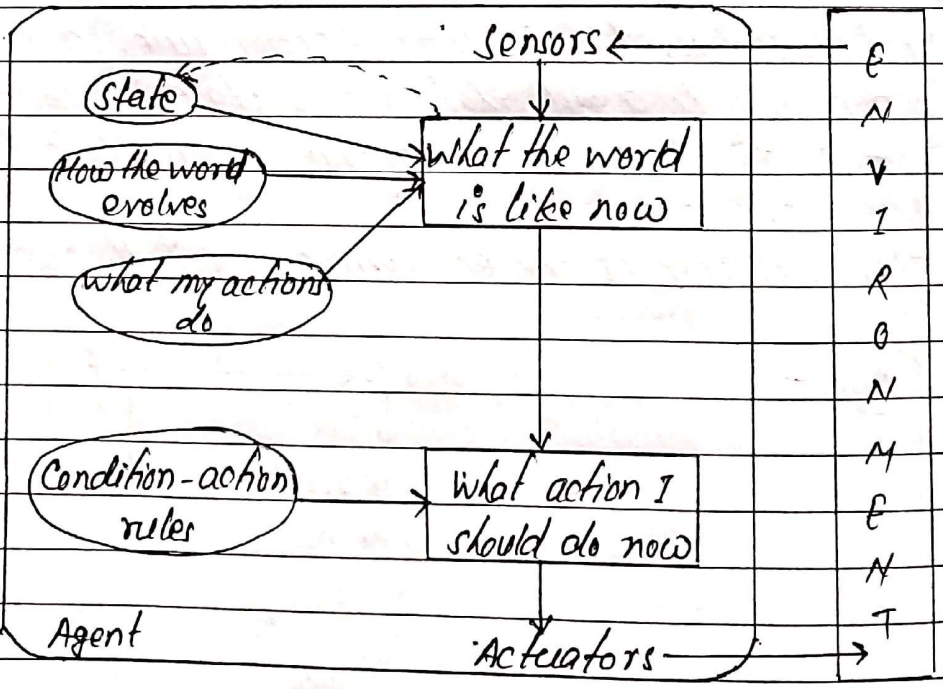
1) Simple Reflex Agent

These agents take decisions on the basis of the current percepts and ignore the history of perceptions.
- It is based on the condition-action rule. A condition-action rule is a rule that maps a state i.e. condition to an action. If the condition is true, then the action is taken else not.
- It works only if the environment is fully observable.



2) Model Based Agents

→ The model based agent can work in a partially observable environment.
→ They use a model of the world to choose their actions. They maintain an internal state.
• Model : It is knowledge about "how the things happen in the world".
• Internal state : It is a representation of the current state based on percept history
→ Updating the state requires the information about :
- How the world evolves.
- How the agent's actions affect the world.

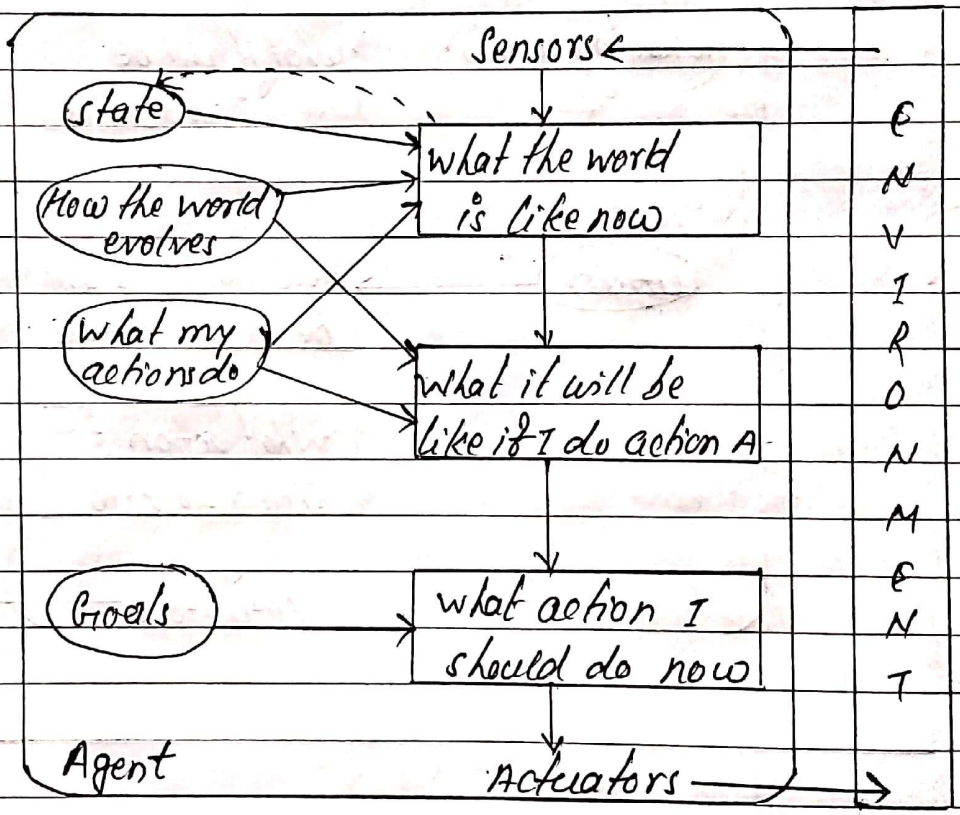


3) Goal Based Agent

- The knowledge of the current state environment is not

always sufficient to decide for an agent to what to do.
- The agent needs to know its goal which describes desirable situations.
- Goal based agent expands the capabilities of the model-based agent by having the "goal" information.
- They choose an action, so that they can achieve the goals.

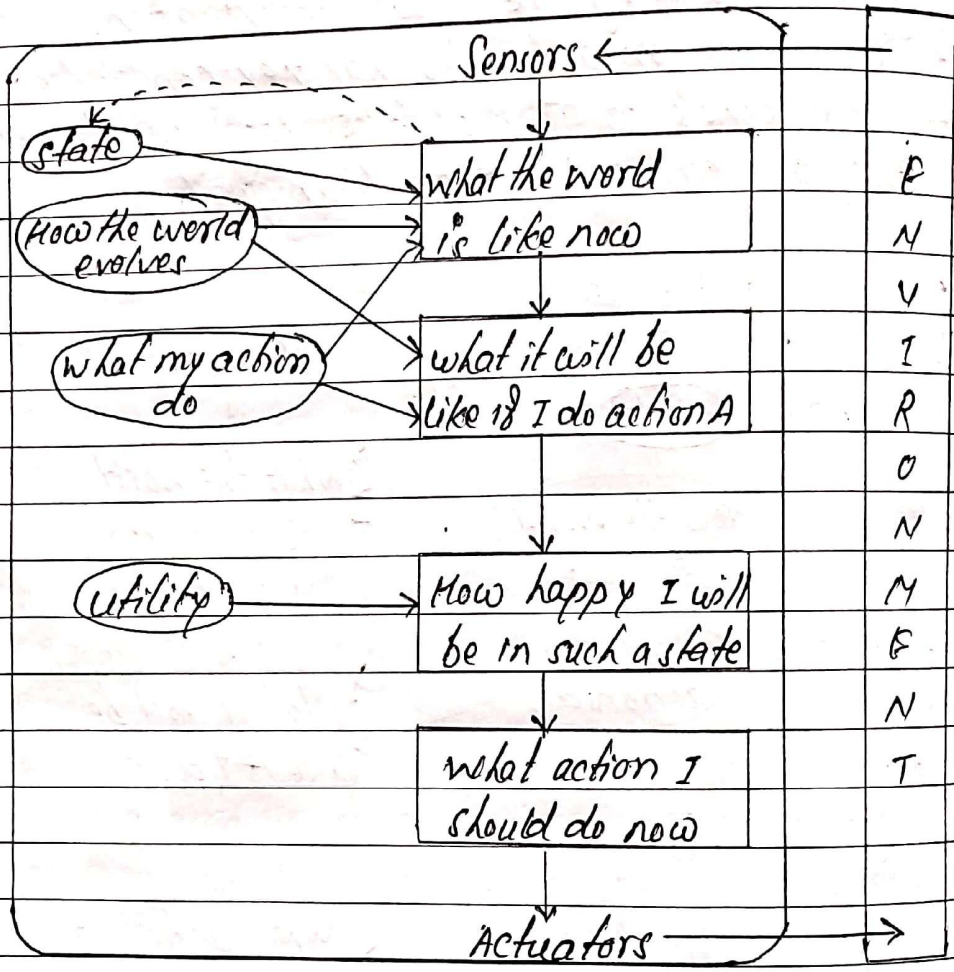
→ These kinds of agents take decisions based on how far they are currently from their goal.



5) Utility-based Agent

- When there are multiple possible alternatives, then to decide which one is best, utility based agents are used.
- They choose actions based on a preference (utility) for each state.

- utility describes how "happy" the agent is.
- The utility function maps each state to a real number to check how efficiently each action achieves the goals.



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